Taking the temperature of phase transitions in cool materials

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Over the previous one-and-a-half centuries, there have been numerous reports describing thermal changes that arise when phase transitions are driven in various materials by changes in some type of field. Most authors employ magnetic fields for this purpose, while some employ stress fields, and others employ electric fields. The use of all three types of field was suggested near the outset by Lord Kelvin, but the overlapping nature of these activities was essentially ignored, despite the common goal of making the materials cool.

The first public meeting of workers with this common goal took the form of a Royal Society Discussion Meeting on 8-9 February 2016. The proceedings presented on the following pages represent a snapshot of activity at the time of the meeting, while the resulting cross-fertilization of knowledge will be manifested in future research activity.

To reflect the order of the presentations in London, first come the papers on electrocaloric effects, where the thermal changes are driven by changes of electric field. Then come the papers on magnetocaloric effects, which use a magnetic field. Last come the papers on mechanocaloric effects, with a stress field. This 'sandwich' structure places the two smaller fields on either side of the more established line of research into magnetocaloric effects. However, the two pieces of 'bread' in the 'sandwich' are not equal, because mechanocaloric effects are currently the least widely studied caloric effect, even though they were discovered before the other two.

Mechanocaloric effects deserve a specific note of explanation, as they comprise elastocaloric effects due to changes of uniaxial stress, and barocaloric effects due to changes of isotropic stress (hydrostatic pressure). The term 'mechanocaloric' has only recently been used for this purpose, but it appears in the Oxford English Dictionary to describe "a phenomenon by which a linear flow of superfluid liquid helium (helium II) generates a difference in temperature between its ends". In future, the present usage may be added.

At the Discussion Meeting, we were particularly honoured and delighted to welcome Gerald Brown of NASA as a session chair. His sole-author 1976 publication showed that the temperature span achieved near room temperature with magnetocaloric gadolinium could be dramatically increased by dumping and absorbing the heat along a fluid column known as a regenerator. The concept of regeneration remains important today in the quest for practical applications of the caloric effects, and regeneration has been exploited in many refrigerator prototypes that have now been demonstrated.

We are very grateful indeed to the Royal Society for organising and funding the Discussion Meeting. It inspired us to organise a fresh set of speakers for a meeting held directly afterwards in Cambridge on 10-11 February 2016, with proceedings scheduled for the June 2016 issue of *APL Materials*. All three caloric strands were then further entwined in Symposium EE11 at MRS Spring 2016, and another such symposium will take place at MRS Spring 2017. Therefore it would appear that one-and-a-half centuries after its inception, the idea of cooling with each type of field is now well and truly established as a common endeavour.